Space Weather Technical Forecast

Issued on Friday, 11 March 2022 at 01:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Geomagnetic activity expected to increase days 3 and 4, with a chance of G1/Minor geomagnetic storms. Active electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours. The largest flare of the past 24 hours, a long duration C-class flare, appears to be from the large plage region to the south of AR2962. It peaked at C2.8 at 10/2057, but is currently on-going. This flare has emitted a large CME which is likely to have an Earth directed component, due to the source location in the northwest quadrant, plus the CME appears wide and generating a full halo. Analysis is currently being undertaken.

There are six numbered sunspot regions on the visible disc, with AR2965 the largest and also magnetically complex, but surprisingly dormant at present. There are also two other large groups, AR2960 and AR2964, with AR2960 also magnetically complex. Yet despite the presence of these regions only a C-class flare from a plage region has occurred. The remaining sunspots on the visible disc are small, weak and magnetically simple.

There are also numerous - mostly small - filaments on the disc at present. The largest of these lifted off the southeastern limb late in the UTC evening of 09 March, with the resultant Coronal Mass Ejection (CME) clearly discernible in coronagraphs. This event has been modelled, and counter to expectations does in fact show marginal influence is possible at Earth from at least the shock either late day 3 (13th) or more likely through day 4 (14th).

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was at background levels and only peaked at 400 km/s at 10/1934 UTC. The solar wind density was predominantly at average levels until 10/1641 UTC, then increased to above average levels, peaking at 32 ppcc at 10/1825 UTC. The IMF was weak and steady until 10/1636 UTC after which time it strengthened to temporarily become strong and peak at 18 nT at 10/2102 UTC. By the end of the day the IMF had lowered slightly, to moderate levels around 14 nT. The north-south component was generally very weakly negative, but increased to become temporarily moderately negative, reaching -9 nT at 10/1900 UTC, after which the Bz rapidly became positive. The phi angle was erratic, but more often negative (towards the Sun), especially before 09/1600UTC, and then generally positive (away from the Sun) after this time. The changes in the solar wind parameters indicated that a CME has arrived, probably the one emitted on 7th March, but this may have swept up and included the CME emitted on 5th March as well.
Geomagnetic activity was mainly Quiet (Kp 1-2) but with an isolated Active (Kp 4) interval 10/2100-2400 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was at Background levels until late in the day, then became slightly elevated in response to the CME being emitted from the C-class flare, but remained below the

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S1 level.

The high energy electron flux (greater than 2 MeV) was High until 10/1910 UTC, with a peak value of 8967 pfu at 10/1720 UTC. After this time the flux rapidly dropped to background to moderate levels, as a result of the increased geomagnetic activity. The corresponding 24-hour integrated electron fluence remained above the Active (1e8 integrated pfu) level, with a steady trend, and reaching 2.88e8 integrated pfu at 11/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low, with further C-class flares, but with a daily Chance of rising to Moderate - the main risk being from AR2965.

Solar Wind / Geomagnetic Activity: No coronal hole high speed streams feature in this forecast period. There are now two CMEs potentially Earth-directed, the first with low confidence from the 9th March southeast quadrant filament. This may influence Earth either late day 3 (13th) or through day 4 (14th). Although modelling is not yet complete yesterday's large CME, it is expected to have an Earth directed component, possibly arriving day 3 and with probably a larger impact that the 9th March CME.

Geomagnetic activity is expected to be Unsettled to Active (Kp 3-4) at first under the residual influence of yesterday's CME arrival, then decreasing mainly Quiet (Kp 0-2) later today and through tomorrow (12th). During day 3 activity is likely to increase again, becoming Unsettled to Active, either under the influence of the 9th March CME but also possibly with the arrival of yesterday's CME. There is a chance of a G1/Minor (Kp 5) Storm each day, but especially during day 3.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain predominantly at Background levels, albeit with a slight chance of rising above-the S1 level.

The high energy (greater than 2 MeV) electron flux is currently at background to moderate levels, but is likely to rebound to reach High levels again today and also tomorrow, especially at the peaks of the diurnal cycles. During days 3 and 4 (13th and 14th), with an likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels again.
The corresponding fluence will start above Active levels (1e8 integrated flux) before decreasing below Active through day 2 or 3, although confidence is low regarding this.

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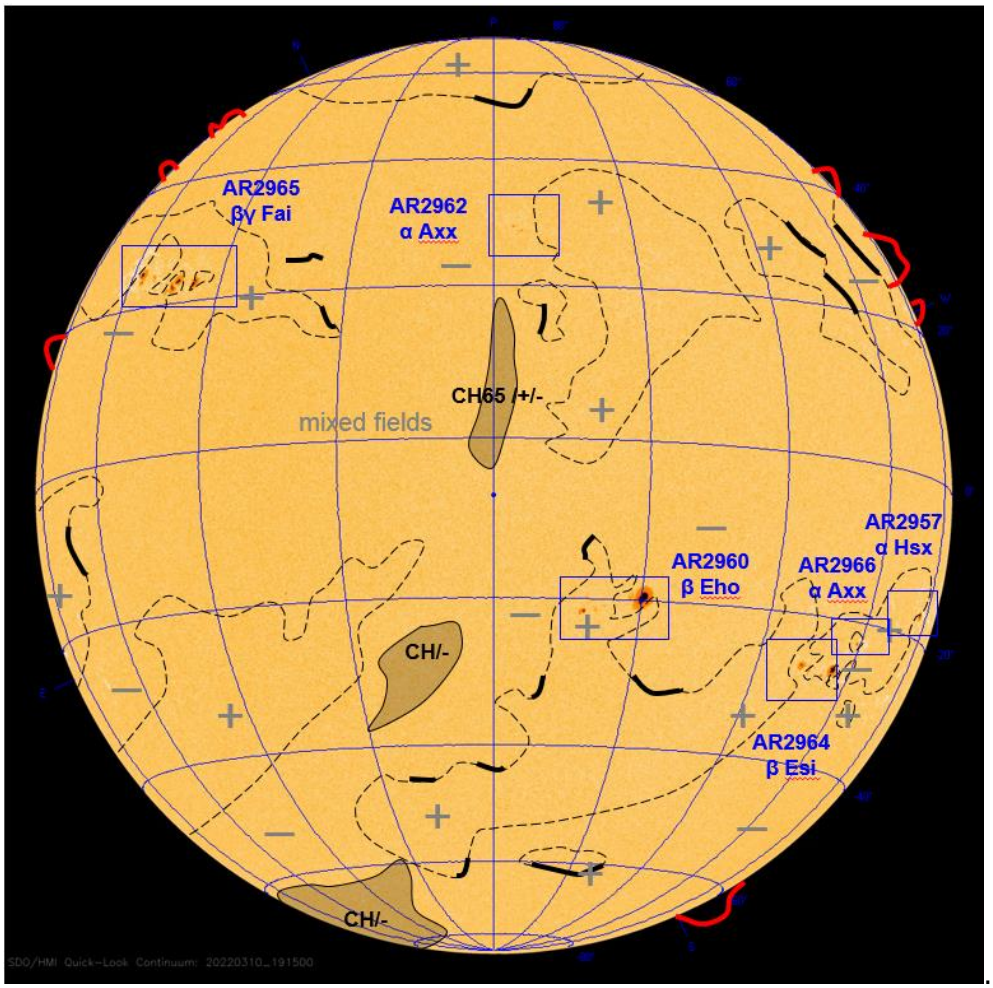
Figure 1. Solar Analysis Valid 10/1915 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are now up to three Earth-directed CMEs in the forecast.
The first is a low confidence CME, due to only a weak signal in SOHO Lasco coronagraph imagery and an uncertain source, leaving the Sun on 05 March. The second was due to a filament eruption late on 06 March, and whilst confidence is higher on the analysis, it is lower for Earth-directed impact with only a glancing interaction due. These CMEs are indicated to arrive on day one (Thursday 10 March) - perhaps merging into a single arrival. The third CME is tied to the evening UTC filament lit off from the southeastern quadrant on 09 March. Despite being from an apparently too far eastward location, there appears to be a degree of interaction between this and the CIR leading the fast wind from CH65 to end the current four-day period, with the result that at least the shock may offer a slightly increased Slight Chance of G1 to round out the UTC weekend.

Confidence in the first two CMEs is increased due to news that the Solar Orbiter magnetometer has reported a direct hit from two CMEs whilst in the Sun-Earth line (reported on Twitter). Given a strong negative Bz-component of the IMF was observed, the risk for G1/Minor Storm intervals has been increased, with arrival expected in the second half of day one (10 March), and a potential magnetic cloud influence continuing through Friday 11 March.
In the absence of the aforementioned CMEs, background solar winds are expected, with the only coronal hole of note on the disc, CH65, not expected to bring any fast wind into Earth until perhaps narrowly beyond this forecast period. Mainly Quiet geomagnetic activity is therefore forecast. There is now a Chance of G1/Minor Storm intervals with any CME arrivals at Earth, most likely occurring before the end of the current working week UTC, but now also again at the end of the UTC weekend.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	20	50	40
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2300	Partial?	SE quadrant filament	36E 18S	445km/s	13/2300UTC	Possible shock, mainly outside period. Low confidence
11/04:06	Full	NW quadrant	Approx 11W 23N	577	Unknown yet	Likely to be Earth directed

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Figure 2: GOES 16 X-ray flux showing the long duration flare.

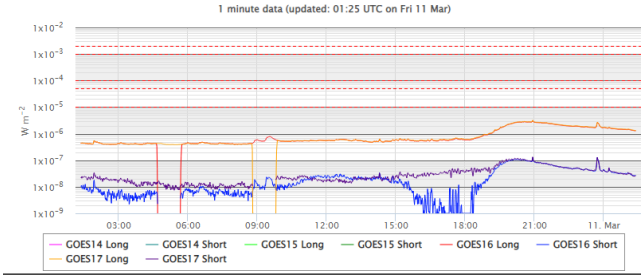
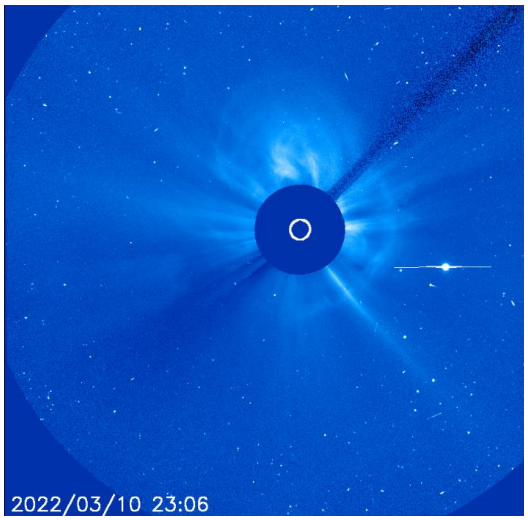


Figure 3: SOHO Lasco C3 image showing the full halo CME



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Radio Blackouts - X-Ray Flares:

There are six numbered sunspot regions, although 2964 and 2966 are hard to discern as they are so close to each other, which has implications on the risks of flares. AR2960 remains one of the most significant regions on the disc, but the penumbra on the trailing spots has diminished to become rudimentary. AR2962 is barely visible as a simple Axx/alpha region. AR2964 showed growth in the penumbra in the leading and trailing spot groups. AR2965 persists as the largest and most complex region on the visible disc, with a recent slight increase in area.
Activity is expected to remain Low with further C-class flares likely. There remains a chance of M-class flares, most likely from AR2965, despite its apparent dormant state at present.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	25	25	25
Very Active	R3 to R5 X Class	No	2	2	2	2

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is currently slightly elevated, under the residual influence of the CME that was emitted yesterday evening. The high energy proton flux is expected to return and then remain predominantly at background levels, albeit with a slight chance of rising above-the S1 level.

The probabilities have been increased very slightly to reflect the potential of a further large CME, either from the northwest quadrant again or from one of the large and complex sunspot regions on the disc.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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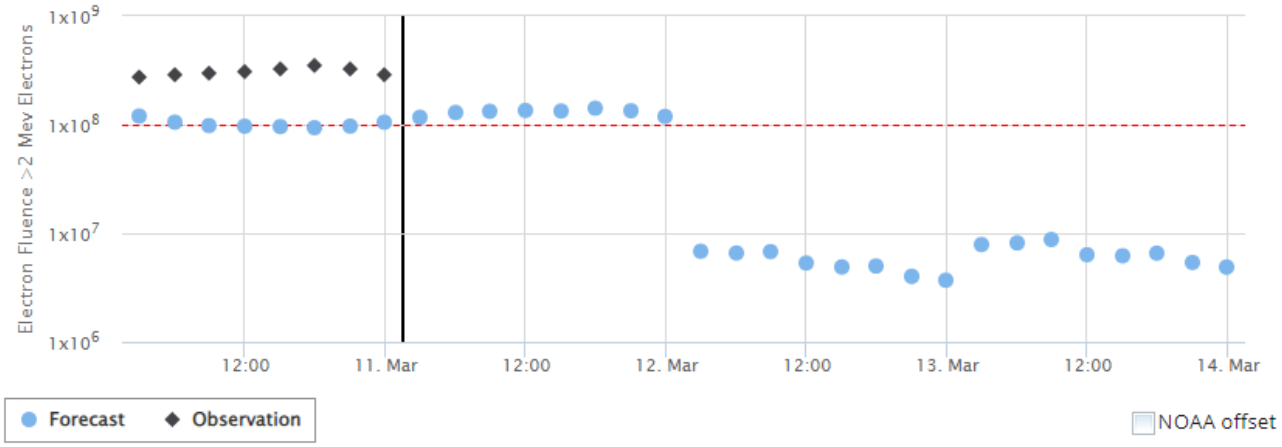
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux is currently at background to moderate levels, but is likely to rebound to reach High levels again today and also tomorrow, especially at the peaks of the diurnal cycles. During days 3 and 4 (13th and 14th), with an likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels again.
The corresponding fluence will start above Active levels (1e8 integrated flux) before decreasing below Active through day 2 or 3, although confidence is low regarding this.
The REFM is currently poor guidance, as it is not able to take account of upcoming CME arrivals.

GEO Electron Environment	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	60	30	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: Met Office REFM model:



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